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औद्योगिक रोबोट परिचालन — गुणधर्म की प्रस्तुति

(पहला पुनरीक्षण)

Indian Standard

MANIPULATING INDUSTRIAL ROBOTS — PRESENTATION OF CHARACTERISTICS

(First Revision)

ICS 25.040.30

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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NATIONAL FOREWORD

This Indian Standard (First Revision) which is identical with ISO 9946 : 1999 'Manipulating industrial robots — Presentation of characteristics' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendations of the Industrial and Production Automation Systems and Robotics Sectional Committee and approval of the Medical Instruments, General and Production Engineering Division Council.

This standard was first published in 1998 based on ISO 9946 : 1991. In this revision,.it has been aligned with latest edition of ISO 9946.

The text of the ISO Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their place, are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 8373 : 1994 Manipulating industrial robots — Vocabulary	IS 14662 : 1999 Manipulating industrial robots — Vocabulary	Identical
ISO 9283 : 1998 Manipulating industrial robots — Performance criteria and related test methods	IS 14533 : 2005 Manipulating industrial robots — Performance criteria and related test methods	do
ISO 9409-1 : 1996[1] Manipulating industrial robots — Mechanical interfaces — Part 1: Plates (form A)	IS 13547(Part 1) : 2003 Manipulating industrial robots — Mechanical interfaces : Part 1 Plates (Form A) (*first revision*)	do
ISO 9787 : 1990[2] Manipulating industrial robots — Coordinate systems and motions	IS 14663 : 1999 Manipulating industrial robots — Coordinate systems and motions	do

Since all the performance criteria referred in Annex A and Annex B are not measurable these are to be agreed to between the manufacturer and the user regarding measurable characteristics.

The Technical Committee responsible for the preparation of this standard will review the provisions of ISO 10218 : 1992 'Manipulating industrial robots — Safety' and will decide about its acceptance for use in conjunction with this standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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[1] Since revised in 2004.

[2] Since revised in 1999.

Indian Standard

MANIPULATING INDUSTRIAL ROBOTS — PRESENTATION OF CHARACTERISTICS

(First Revision)

1 Scope

This International Standard specifies how characteristics of robots shall be presented by the manufacturer.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 8373:1994, *Manipulating industrial robots — Vocabulary.*

ISO 9283:1998, *Manipulating industrial robots — Performance criteria and related test methods.*

ISO 9409-1:1996, *Manipulating industrial robots — Mechanical interfaces — Part 1: Plates (form A).*

ISO 9787:—1), *Manipulating industrial robots — Coordinate systems and motion nomenclatures.*

ISO 10218:1992, *Manipulating industrial robots — Safety.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 8373 and the following definition apply.

3.1
centre of the working space (C_w)
is the position of the wrist reference point when each active joint in the arm is in the middle position of its moving range

4 Units

Unless otherwise stated, all dimensions are as follows:

— length in millimetres (mm);

— angle in radians (rad) or degrees (°);

— time in seconds (s);

— mass in kilograms (kg);

— force in newtons (N);

— velocity in metres per second (m/s), radians per second (rad/s) or degrees per second (°/s).

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1) This International Standard is subject to revision and the year of publication will be inserted at a later stage.

5 Characteristics

5.1 General

The manufacturer shall provide information related to the various characteristics and requirements as described in this clause as part of the robot documentation.

5.2 Application

The manufacturer shall specify the main type(s) of application(s) for which the robot is intended.

Examples of typical applications are

- handling;
- assembly;
- spot welding;
- arc welding;
- machining;
- spray painting;
- adhesive/sealing;
- inspection.

5.3 Power source

The manufacturer shall specify all external power sources, including type (e.g. electrical, hydraulic, pneumatic or combination) required for proper operation of the robot (e.g. mechanical structure motion actuators, control, auxiliary equipment [e.g. gripper]), together with the maximum power consumption required from each. These specifications shall also include permissible ranges and fluctuations.

The manufacturer shall also specify the type of power utilized to control axis and auxiliary motion (e.g. electric, hydraulic, pneumatic). Where more than one type of power is utilized, the manufacturer shall include a breakdown by individual motion.

5.4 Mechanical structure

The manufacturer shall specify the type of the mechanical structure and the number of mechanical axes. An outline drawing of the structure shall be provided detailing the axis motions. This drawing may be part of the drawing required for describing the working space (see 5.5).

Examples of mechanical structures:

- rectangular robot;
- cylindrical robot;
- polar robot;
- articulated robot.

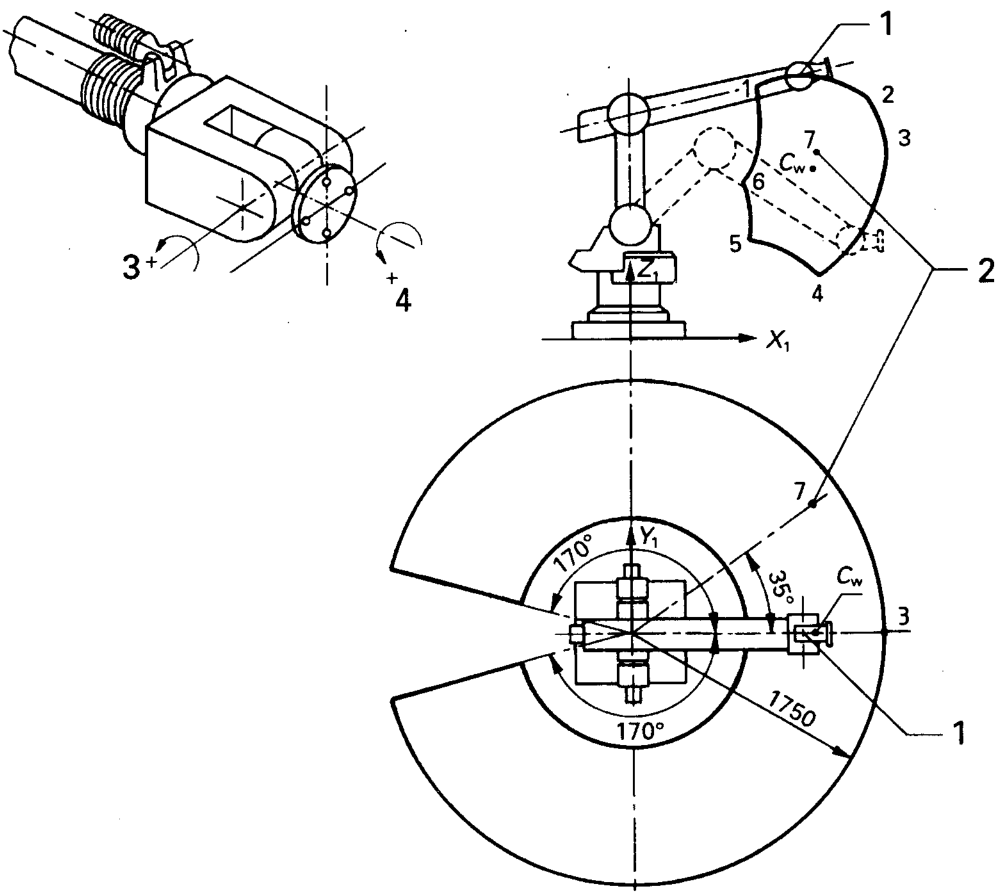
If the robot is mobile, the way in which it is guided shall be indicated.

5.5 Working space

The boundaries of the working space of the wrist reference point including the alignment pose and centre of the working space (C_W) shall be illustrated in a drawing with at least two views (one the projection of the locus of the maximum reach of the robot arm in the base coordinate X_1 - Y_1 plane (see ISO 9787) and the other the projection of the locus of the maximum reach of the arm on the base coordinate X_1 - Z_1 plane). The drawing shall also provide information on any limitation of secondary axis motion at any point(s) in the working space of the wrist reference point (see figure 1 for an example of a 5-axis robot and figure 2 for an example of a 6-axis robot).

In the drawings, it is recommended that the details of the working space and range of movement of secondary axes are given in tabular form as shown in the examples of figures 1 and 2.

Dimensions in millimetres



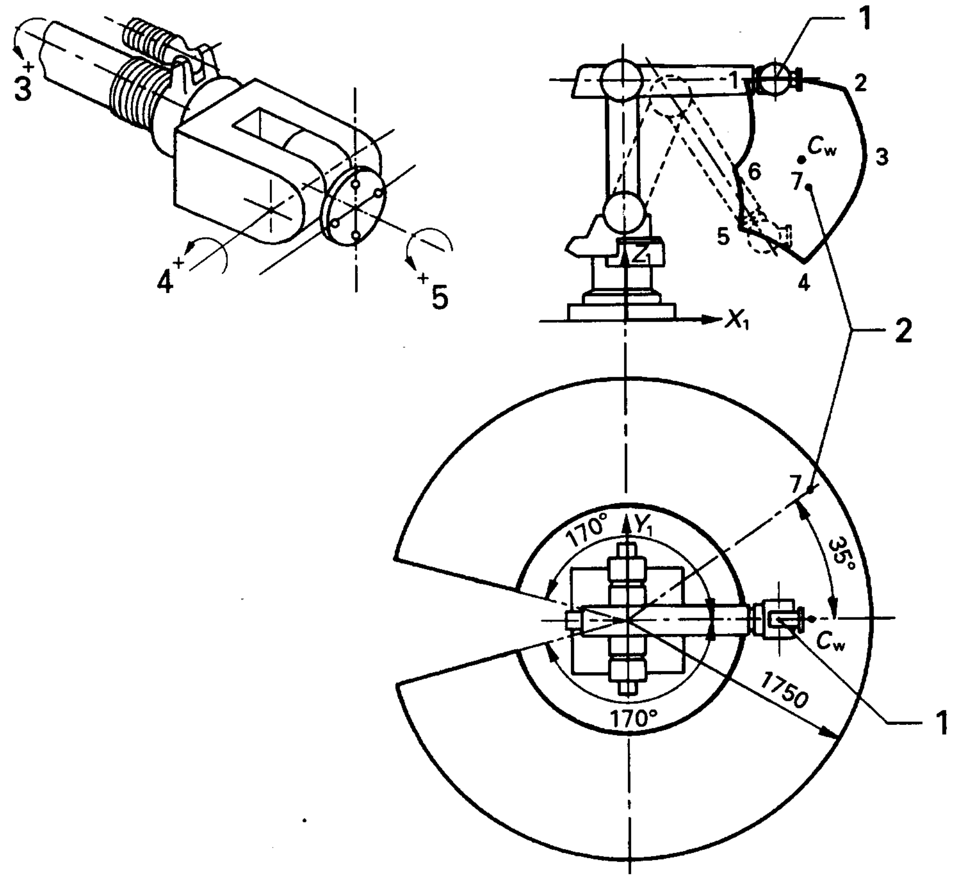
Key

1 Wrist reference point
2 Alignment pose
3 4th axis
4 5th axis

Point in space	Working space of the wrist reference point		Range of movement of secondary axes	
	X_1 (mm)	Z_1 (mm)	4th	5th
1	925	1 635	+ 75° – 90°	+ 170° – 150°
2	1 610	1 550	+ 75° – 90°	± 180°
3	1 750	1 140	+ 75° – 105°	± 180°
4	1 310	345	+ 45° – 120°	± 180°
5	870	600	+ 45° – 120°	+ 150° – 170°
6	840	1 000	+ 75° – 120°	+ 140° – 150°
7	1 350	750	–	–

Figure 1 — Example of a 5-axis robot working space

Dimensions in millimetres



Key

1 Wrist reference point
2 Alignment pose
3 4th axis
4 5th axis
5 6th axis

Point in space	Working space of the wrist reference point		Range of movement of secondary axes		
	X_1 (mm)	Z_1 (mm)	4th	5th	6th
1	925	1 635	± 210°	+ 75° – 90°	+ 170° – 150°
2	1 610	1 550	± 210°	+ 75° – 90°	± 180°
3	1 750	1 140	± 210°	+ 75° – 105°	± 180°
4	1 310	345	± 210°	+ 45° – 120°	± 180°
5	870	600	± 210°	+ 45° – 120°	+ 150° – 170°
6	840	1 000	± 210°	+ 75° – 120°	+ 140° – 150°
7	1 350	750	–	–	–

Figure 2 — Example of a 6-axis robot working space

5.6 Coordinate system

The manufacturer shall specify base and mechanical interface coordinate systems in accordance with ISO 9787. Any deviations to ISO 9787 shall be stated by the manufacturer.

5.7 External dimensions and mass

The manufacturer shall specify external dimensions in millimetres (mm), and mass in kilograms (kg) of the mechanical structure and control unit.

5.8 Base mounting surface

The manufacturer shall provide the base mounting surface description (for example in a drawing) and recommendations on the mounting of the robot base necessary to ensure that safe operation and rated performances are obtained.

The permissible mounting positions and orientations of the robot should be specified together with any limitations in safety or performance relative to each position and orientation.

5.9 Mechanical interface

The manufacturer shall provide the mechanical interface description including any drawings, specifications and recommendations necessary for mounting the end effector to the robot wrist. Where applicable, reference to appropriate International Standard(s) shall be provided (see, for example, ISO 9409-1).

5.10 Control

The manufacturer shall specify

— Control unit type and all relevant information, for example its capability, special provisions (e.g. control schemes).

— Task program memory storage:
basic capacity
maximum capacity

— Motion control method:
pose-to-pose (PTP)
continuous path (CP)

— Motion control type:
servo
non-servo

— Path interpolation method:
linear
circular
parabolic
other

— Number of controlled axes:
basic number of axes
additional number of axes (with interpolation)
additional number of axes (without interpolation)

— Pendant/operator controls

— Input/output interfaces:
signal types and levels
continuous or multiplexed signal

- Data interfaces:
  data formats/control formats

- Network interfaces:
  physical characteristics
  communication protocols

5.11 Task programming and program loading

The manufacturer shall specify the type of task programming method and the means used for program loading.

5.11.1 Examples of programming methods

- Manual Data Input

- Teach
  manually leading the robot end effector
  manually leading the robot on a mechanical simulating device
  manually programming by a teach pendant

- Off-line

- Goal directed

5.11.2 Examples of program loading means

- Data links

- Disks

- Tapes

- Memory cards

5.12 Environment

The manufacturer shall specify the limits of environmental conditions within which the rated performances can be achieved, or the degree of protection of the robot against environmental conditions.

The manufacturer shall specify the limits for storage and operation without damage when different.

Environmental conditions include but are not necessarily limited to

- Temperature (operating and storage/transport)
  (degrees Celsius) (°C)

- Relative humidity (per cent) (%)

- Altitude limit (metres) (m)

- Electromagnetic interference

- Atmospheric contaminants

- Vibrations

5.13 Load

The various load characteristics shall be specified in terms of

- mass (kilograms) (kg)

— thrust (newtons) (N)

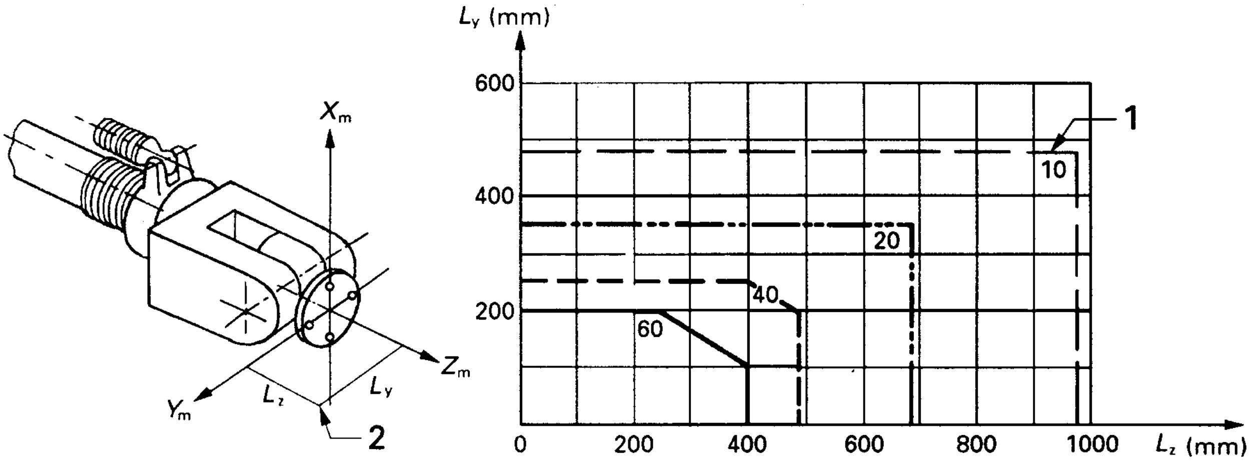
— torque (newton metres) (N·m).

These values should be stated in terms of the mechanical interface coordinate system.

The manufacturer shall specify the rated load of the robot. It is recommended that the relation between the maximum mass and the position of the centre of gravity of the mass is shown as in figure 3.

Where required, the manufacturer shall specify any limitation of the load and what influence it has on other specified characteristics and conditions (e.g. velocity, acceleration). Where the robot can carry some additional mass (e.g. mass on arm) it shall be specified.

Where required, the manufacturer shall specify the maximum thrust and maximum torque (see figure 4). Where thrust and torque are dependent on the robot configuration then this shall be specified.

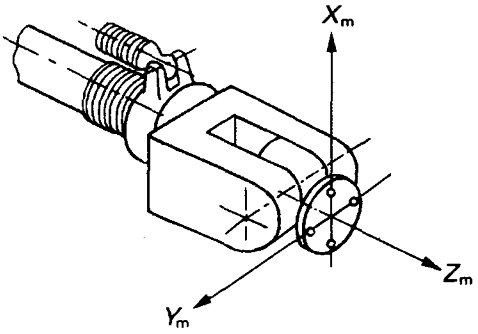


Key

1 Mass (kg)

2 Centre of gravity of the mass

Figure 3 — Load diagram



Axis	Thrust N	Torque N·m
X_m Y_m Z_m		

Figure 4 — Thrust and torque values

5.14 Velocity

Unless otherwise stated, the manufacturer shall specify the velocity under the following conditions:

- at a constant rate of distance per unit of time where no acceleration or deceleration is active;
- with the rated load applied.

The manufacturer shall specify at least

- the maximum individual axis velocity for each axis;
- the rated path velocity with the shape of the path and the related performance criteria.

5.15 Resolution

For servo-controlled axes, the manufacturer shall specify the resolution of each axis in terms of millimetres, or radians, or degrees, whichever is appropriate.

5.16 Performance criteria

The manufacturer shall provide information in accordance with ISO 9283 for those performance criteria which are guaranteed. The performance criteria in ISO 9283 are the following:

- pose accuracy and pose repeatability;
- multi-directional pose accuracy variation;
- distance accuracy and distance repeatability;
- position stabilization time;
- position overshoot;
- drift of pose characteristics;

- exchangeability;
- path accuracy and path repeatability;
- path accuracy on reorientation;
- cornering deviations;
- path velocity characteristics;
- minimum posing time;
- static compliance;
- weaving deviations.

5.17 Safety

The manufacturer shall specify that the robot complies with ISO 10218 or other relevant safety standards.

Annex A
(informative)

Recommended format of presentation for robot specifications

Date of issue ....

Trademark ....

Country ....

Manufacturer's name ....

Model ....

Type ....

Main application(s) (see 5.2) ....

Power source (see 5.3):
- **external (types and characteristics)** ....
- **maximum power consumption** ....
- **robot axis consumption** ....
- **auxiliary motions consumption** ....

Mechanical structure, working space and coordinate system (see 5.4, 5.5 and 5.6)

Drawing

....

....

External dimensions and mass (see 5.7)

Mechanical structure	**Control unit**
Mass .... **kg**	**Mass** .... **kg**

Base mounting surface (see 5.8)

Drawing

....
....
....

Mechanical interface (see 5.9)

Drawing

....
....
....

Control (see 5.10)

Control unit type ....
Number of controlled axes ....

Task program memory storage
  basic capacity ....
  max. capacity ....

Motion control type ....
Motion control method ....
Path interpolation method ....

Pendant/operator controls ....
....

Input/output interfaces ....
....

Data/network interfaces ....
....
....

Programming method and loading means (see 5.11) ....

Environment (see 5.12)	Operating	Storage/transport
Temperature	.... °C	.... °C
Relative humidity	.... %	.... %
Altitude limit	.... m	.... m
Electromagnetic interferences	....	....
....	....	....
....	....	....
Atmospheric contaminants	....	....
Vibrations	....	....
....	....	....
....	....	....

Load (see 5.13)

Rated load

Load diagram

Limiting load ....

Additional mass..

Axis	Thrust	Torque
X_m	.... N	.... N·m
Y_m	.... N	.... N·m
Z_m	.... N	.... N·m

Remarks: ....

....

....

....

Axis number	Individual axis velocity (see 5.14)	Resolution (see 5.15)
1		
2		
3		
4		
5		
6		

Performance criteria (see 5.16)

Pose characteristics

100 % and optional 10 % of rated load,
100 % and 50 and/or 10 % of rated velocity

AP_p =
AP_a =
AP_b =
AP_c =
RP_l =
RP_a =
RP_b =
RP_c =

vAP_p =
vAP_a =
vAP_b =
vAP_c =
AD =
RD =

Stabilisation time =
Position overshoot =
For limit band =

Drift diagram

Posing time

Distance	Time

Static compliance

.... mm/N along X_1
.... mm/N along Y_1
.... mm/N along Z_1

Path and weaving characteristics

Shape of the path..

100 % and optional 10 % of rated load

....

Rated path velocity

10 %	50 %	100 %	100 % of rated path velocity
AT_p =	AT_p =	AT_p =	=
AT_a =	AT_a =	AT_a =	=
AT_b =	AT_b =	AT_b =	=
AT_c =	AT_c =	AT_c =	=
RT_p =	RT_p =	RT_p =	=
RT_a =	RT_a =	RT_a =	=
RT_b =	RT_b =	RT_b =	=
RT_c =	RT_c =	RT_c =	=
CR =	CR =	CR =	=
CO =	CO =	CO =	=
WS =	WS =	WS =	=
WF =	WF =	WF =	=

Path velocity characteristics

100 % and optional 10 % of rated load

		AV	RV	FV
Rated path velocity	10 %			
	50 %			
	100 %			
100 % of rated path velocity		=	=	=

Safety (see 5.17)

Compliance with ....

Annex B
(informative)

Description of the symbols of performance criteria — Abstract from ISO 9283

The symbols used in annex A for performance criteria comply with ISO 9283. The description of these symbols is as follows:

AP	pose accuracy
RP	pose repeatability
*v*AP	multi-directional pose accuracy variation
AD	distance accuracy
RD	distance repeatability
t	position stabilization time
OV	position overshoot
*d*AP	drift of pose accuracy
*d*RP	drift of pose repeatability
E	exchangeability
AT	path accuracy
RT	path repeatability
CR	cornering round-off error
CO	cornering overshoot
AV	path velocity accuracy
RV	path velocity repeatability
FV	path velocity fluctuation
WS	weaving stroke error
WF	weaving frequency error

Indices a, b, c indicate an orientation characteristic about the *X*-, *Y*-, *Z*-axis. Index p indicates a position characteristic.

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Amendments Issued Since Publication

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BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 2323 0131, 2323 3375, 2323 9402 *website* : www.bis.org.in

Regional Offices:		Telephones
Central	: Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	2323 7617 2323 3841
Eastern	: 1/14 C.I.T. Scheme VII M, V.I.P. Road, Kankurgachi KOLKATA 700054	2337 8499, 2337 8561 2337 8626, 2337 9120
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